JC02 Rec'd PCT/PTO 22 DEC 2000

FORM PTO-1390 (REV 10-2000) U.S. DEPARTMENT COMMERCE AND TRADEMARK OFFICE		ATTORNEY'S DOCKET NUMBER 14XZ00074
TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371		U.S. APPLICATION NO.(If known see 37 CFR 1.5) 09/720541
INTERNATIONAL APPLICATION NO. PCT/IB00/00606 (PCT/US00/11617)	INTERNATIONAL FILING DATE 28 April 2000	PRIORITY DATE CLAIMED 28 April 1999
TITLE OF INVENTION CT/MR FUSED IMAGE PRESENTATION ALGORITHM		
APPLICANT(S) FOR DO/EO/US GE MEDICAL SYSTEMS SA		

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This is an express request to promptly begin national examination procedures (35 U.S.C. 371 (f)).
4. ☐ The US has been elected by the expiration of 19 months from the priority date (PCT Article 31).
5. ☒ A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. ☐ is attached hereto (required only if not communicated by the International Bureau).
   b. ☒ has been communicated by the International Bureau.
   c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☒ An English language translation of the International Application as filed (35 U.S.C. 371 (c) (2)).
7. ☒ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371 (c) (3))
   a. ☐ are attached hereto (required only if not communicated by the International Bureau).
   b. ☐ have been communicated by the International Bureau.
   c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   d. ☒ have not been made and will not be made.
8. ☐ An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371 (c) (3)).
9. ☒ An oath or declaration of the inventor(s) (35 U.S.C. 371 (c) (4)).
10. ☐ A English language translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371 (c)(5)).

Items 11. To 16. Below concern document(s) or information included:

11. ☒ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. ☒ A **FIRST** preliminary amendment.
    ☐ A **SECOND OR SUBSEQUENT** preliminary amendment
14. ☐ A substitute specification.
15. ☐ A Change of power of attorney and/or address letter.
16. ☐ Other items or information:
    Unsigned Declaration; a signed Declaration will be provided in due course
    PCT/IB/308
    Title Page of Published International Application No. WO 00/67202

Express Mail No. EL639844667US　　Date of Deposit: December 22, 2000

I hereby certify that the application is being deposited with the United States Postal Service under 37CFR 1.10 on the date indicated above and is addressed to the Commissioner Patents and Trademarks, Washington D.C. 20231.

Maureen Egan
Printed Name

M Egan
Signature

528 Rec'd PCT/PTO 22 DEC 2000

U.S. APPLICATION NO. (if known see 17 CFR 1.5)	INTERNATIONAL APPLICATION NO.	ATTORNEY'S DOCKET NUMBER
09/720541	PCT/IB00/00606 (PCT/US00/11617)	14XZ00074

17. ☐ The following fees are submitted: — CALCULATIONS — PTO USE ONLY

BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)):

Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO — $1,000.00

International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO — $860.00

International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445 (a) (2)) paid to USPTO — $710.00

International preliminary examination fee paid to USPTO (37 CFR 1.482) but all claims did not satisfy provisions of PCT Article 33(1) - (4) — $690.00

International preliminary examination fee paid to USPTO (37 CFR 1,482 and all claims satisfied provisions of PCT Article 33(1)-(4) — $100.00

				CALCULATIONS	PTO USE ONLY
ENTER APPROPRIATE BASIC FEE AMOUNT =				$ 860.00	
Surcharge of $130.00 for furnishing the oath or declaration later than ☒ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492 (e)).				$ 130.00	
CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE		
Total claims	14 - 20 =	0	x $18.00	$	
Independent claims	2 - 3 =	0	x $80.00	$	
MULTIPLE DEPENDENT CLAIM(S) (if applicable)			-$270.00	$	
TOTAL OF ABOVE CALCULATIONS =				$ 990.00	
☐ Applicant claims small entity status. See 37 CFR 1.27. The fees indicated above are reduced by ½.				$	
SUBTOTAL =				$ 990.00	
Processing fee of $130.00 for furnishing the English translation later ☐ 20 ☐ 30 than months from the earliest claimed priority date (37 CFR 1.492 (f)).				$	
TOTAL NATIONAL FEE =				$ 990.00	
Fee for recording the enclosed assignment (37 CFR 1.21 (h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). $40.00 per property +				$	
TOTAL FEES ENCLOSED =				$ 990.00	
				Amount to be: refunded	$
				charged	$

a. ☐ A check in the of $ _____ to cover the above fees is enclosed.

b. ☒ Please charge my Deposit Account No. 09-0470 in the amount of $ _____ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. **09-0470.** A duplicate copy of this sheet is enclosed.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137 (a) or (b)) must be filed and granted to restore the applications to pending status.

SEND ALL CORRESPONDENCE TO:

Jay L. Chaskin
GENERAL ELECTRIC COMPANY
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Fairfield, CT 06431

Signature

Jay L. Chaskin
Name

24030
REGISTRATION NUMBER

#3

PATENT
14XZ00074

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of
KNOPLIOCH ET AL

: CT/MRI FUSED IMAGE PRESENTATION ALGORITHM

Serial No.: 09/720,541

: Group Art Unit:

Filed: April 28, 1999

: Examiner:

June 25, 2001

SECOND PRELIMINARY AMENDMENT AND

NOTIFICATION OF MISSING REQUREMENTS UNDER 35 U.S.C. 371

BOX PCT
Assistant Commissioner for Patents
Washington, D.C. 20231

IN THE WRITTEN DESCRIPTION:

Enclosed herewith is a substitute written description to replace in its entirety the written description as filed for entry into the United States as a designated/elected office.

IN THE CLAIMS:

Enclosed herewith is an amended claim 12 and a clean copy thereof.

Enclosed herewith is new claim 25.

REMARKS

In response to the above Notice (PCT/DO/EO/905 and 917) mailed 21 May 2001 enclosed herewith is a copy of the Notice and a Declaration in compliance with 37 CFR 1.497(a) and (b) identifying the International Application Number and international filing date. The surcharge under 37 CFR 1.492(e) has already been charged to applicant's Deposit Account.

CERTIFICATE OF MAILING

I hereby certify that this correspondence is being deposited with sufficient postage to the United States Postal Service as First Class Mail in an envelope addressed to: Box PCT, Assistant Commissioner for Patents, Washington, DC 20231, on the date indicated below.

Dolores K. Tillson

Dolores K. Tillson

Date: June 21, 2001

The enclosed substitute written description conforms the patent application written description to US patent practice and improves grammatical usage in the text. No new matter is presented. The applicant requests that the substitute written description be used as the basis for examination of the application.

Claim 12 has been amended to remove a lack of antecedent basis recited in the claim.

New claim 25 is presented herewith for examination.

Respectfully submitted,
KNOPLIOCH ET AL.

By____________________
Jay L. Chaskin
Attorney for Applicant

AMENDED CLAIMS

12 (amended). The method according to claim 11, wherein a two-dimensional recentering of both MRI and scanner images is carried out by means of at least one rotation and/or translation operation, so that a pixel of the scanner image of coordinates (x,y) and a pixel of the MRI image of the same coordinates (x,y) represent the same portion of the [organ X-rayed] object.

25 (new) A method for combining first and second radiographic images of an object to provide a third image comprising the steps of:

providing the first image by CT scanning;

providing the second image by MR scanning;

recentering the first and second images by a two-dimensional rotation and/or translation so that the coordinates of the CT image and the MR image represent the same portion of the object;

fixing in the CT image gray scale levels corresponding to upper and lower limits of the CT interval;

fixing in the MR image gray levels corresponding to upper and lower limits of the MR interval;

combining the first and second images to provide the third image by linear interpolation by integration the respective lower and upper limits of the CT interval and the respective lower and upper limts of the MR image, the third image having gray levels which lie within the CT interval are replaced by pixels of the same coordinates in the MR image.

12. The method according to claim 11, wherein a two-dimensional recentering of both MRI and scanner images is carried out by means of at least one rotation and/or translation operation, so that a pixel of the scanner image of coordinates (x,y) and a pixel of the MRI image of the same coordinates (x,y) represent the same portion of the object.

09/720541

Rec'd PCT/PTO 27 JUN 2001

METHOD AND SYSTEM OF FUSION OF TWO DIGITAL RADIOGRAPHIC IMAGES

BACKGROUND OF THE INVENTION

The invention concerns the fusion of two digital images of an object, the first image of which favors a particular constituent of the object, while the second image favors another.

It has a particularly important application in the medical field, in which a first image of a body organ obtained by scanning is fused with a second image of the same organ obtained by magnetic resonance imaging (MRI).

In fact, an image obtained by means of a scanner particularly reveals the bony part. In such an image, the bony part is white and all the other parts, especially, the soft tissues, are of a homogeneous gray without contrast. On the other hand, an image obtained by means of MRI reveals the soft tissues in different shades of gray levels and the other parts like the bony parts and empty space are black.

In general, in the medical field a scanner image is fused with an MRI image by integrating the pixels of the bony parts of the scanner image in the MRI image.

The scanner images possess an absolute scale of gray levels, that is, all the scanner images are compatible with one another, in the sense that a given gray level always represents a particular organ. This absolute scale is the Hounsfield scale, composed of positive and negative numbers, in which the 0 level is the gray level of water.

An MRI image does not possess an absolute scale. The gray levels depend on the patient and on the image acquisition conditions. Therefore, from one MRI image to another, the muscle, for example, as soft tissue, is not

represented by the same gray level. Thus, fusion of an MRI image with a scanner image results in a final image whose scale is not absolute.

In other words, the fusion of an image possessing an absolute scale with another image not possessing an absolutely scale results in a final image not possessing any absolute scale.

Furthermore, an image not possessing any absolute scale cannot be used by any of the current scanner image processing software. In fact, all of that software uses a standard gray level format, which is the Hounsfield scale. Thus, a final image originating from the fusion of both scanner and MRI images is incompatible with any scanner image processing software. It is necessary to develop specific image processing software not calibrated on the Hounsfield scale, in order to be able to use the final image.

BRIEF SUMMARY OF THE INVENTION

An embodiment of the invention provides a solution to that problem by a scaling of the gray levels of the MRI image, in order to render the final image compatible with all scanner image processing software. In other words, the final image will be calibrated on the Hounsfield scale.

It is an advantage of an embodiment of the invention to reduce the cost of investment in the development of specific software, if it is desired to carry out digital processing on the final image.

An embodiment the invention uses a final image of as an image source for standard radiotherapy software, which is not the case with the fused images in the present state of the art.

An embodiment of the invention proposes a method of fusion of a first digital radiographic image obtained as a result of scanning with a second digital radiographic image obtained by magnetic resonance imaging (MRI).

In an embodiment of the invention, a CT interval of gray levels is selected in the scanner image and each pixel of the scanner image having a gray level lying within the CT interval is replaced by a pixel obtained by digital processing of the pixel of the same coordinates as the MRI image. The final image therefore corresponds to the scanner image in which the pixels of gray levels lying within the CT interval are thus modified.

Furthermore, with a view to effective digital processing, a two-dimensional recentering of both MRI and scanner images may be carried out by means of at least one rotation and/or translation operation, so that a pixel of the scanner image of coordinates (x,y) and a pixel of the MRI image of the same coordinates (x,y) represent the same portion of the organ X-rayed.

In other words, the range of gray levels corresponding to the soft tissues is replaced by a new range of gray levels. The values of the gray levels of that new range are obtained from an algorithm introducing certain gray levels of the MRI image. For a given pixel of the CT interval in the scanner image, the algorithm calculates the gray level value of the new pixel from a pixel of the MRI image having the same coordinates as the pixel of the CT interval having to be replaced.

In an embodiment of the invention, the upper limit B_{CT} of the CT interval is fixed at a gray level value on the Hounsfield scale, the gray level corresponding to the highest value of the gray levels representing the soft tissues visualized on the scanner image. The lower limit A_{CT} of the CT interval is fixed at a gray level value on the Hounsfield scale, the gray level corresponding to the lowest value of the gray levels representing soft tissues visualized on the scanner image.

More precisely, two thresholds are fixed, defining the CT interval corresponding to the soft tissues in the scanner image.

In practice, B_{CT} is fixed as the highest value of the soft tissues in the scanner image and A_{CT} is fixed as the lowest value of the soft tissues in the scanner image.

The interval thus selected is an interval included in the Hounsfield scale, since the scanner image is calibrated on that scale.

In general, in an embodiment of the invention, one selects an MR interval of gray levels in the MRI image, whose upper limit B_{MR} corresponds to a gray level above which the pixels are white, and whose lower limit A_{MR} corresponds to a gray level below which the pixels are black.

In other words, that interval takes into account all of the variation of gray levels in the MRI image. This variation, this contrast, represents the useful information on the soft tissues.

There are then two intervals, a first CT interval in the scanner image included in the Hounsfield scale and a second MR interval in the MRI image not linked to the Hounsfield scale. These two intervals represent a framing of the soft tissues.

In an embodiment of the invention, the digital processing consists of a linear interpolation by means of an affine function integrating the value of the lower limit A_{CT} and upper limit B_{CT} of the CT interval in the scanner image and the value of the lower limit A_{MR} and upper limit B_{MR} of the MR interval in the MRI image.

Carrying out a linear interpolation makes it possible to respect the choice of contrast in the MRI image.

Preferably, for a scanner pixel having a gray level V_{CT} lying within the CT interval, the gray level V_{MR} of the pixel of the same coordinates in the MRI image is determined, and then a gray level in the CT interval is determined from the affine function and from the level V_{MR}. The gray level V_{OUT} of each pixel of the final image can then be obtained by the following algorithm:

- if $V_{CT} < A_{CT}$, then

1) $V_{OUT} = V_{CT}$,

- if $V_{CT} > B_{CT}$, then

2) $V_{OUT} = V_{CT}$,

- if $A_{CT} < V_{CT} < B_{CT}$, then

3) $V_{OUT} = A_{CT} + (B_{CT} - A_{CT})\,(V_{MR} - A_{MR})/(B_{MR} - A_{MR})$.

In other words, while maintaining the resolution of the MRI image, the MRI image is scaled so that the black level A_{MR} of the MRI image corresponds to the lowest value A_{CT} of the soft tissues in the scanner image. Likewise, the white level B_{MR} of the MRI image corresponds to the highest value B_{MR} of the soft tissues in the scanner image.

In fact:

- for $V_{MR} = B_{MR}$, highest gray level in the MR interval of the MRI image,

one obtains by 3) $V_{OUT} = B_{CT}$, highest gray level in the CT interval of the scanner image,

- and for $V_{MR} = A_{MR}$, lowest gray level in the MR interval of the MRI image,

one obtains by 3) $V_{OUT} = A_{CT}$, lowest gray level in the CT interval of the scanner image.

Scaling causes the MR interval not calibrated on the Hounsfield scale of the MRI image to undergo a digital processing which makes it correspond to the CT interval lying within the Hounsfield interval.

Thus, all the gray level values V_{OUT} of the final image will be contained in the Hounsfield scale, which is the standard scale of scanner image processing.

The invention is also directed to a system of fusion of a first digital radiographic image obtained by scanning with a second digital radiographic image obtained by MRI, comprising:

means for reading pixels of the scanner image, the gray levels of which lie within a predetermined CT interval;

means for reading pixels of the MRI image, the coordinates of which are identical to those of the pixels of the CT interval of the scanner image; and

means for calculation of a third image composed of the scanner image in which the pixels whose gray levels lie within the CT interval are replaced by pixels obtained by digital processing of the pixels of the same coordinates as the MRI image in order to obtain an image making possible visualization of the soft tissues and bony tissues.

The final image obtained is of the scanner type. It can therefore be processed by standard software such as Advantage Sim or even Advantage Windows 3D Viewer, which is not the case with the fusion images of the prior art. The methods of the prior art require the use of specific software in order to be able to process their fusion images.

Other advantages and characteristics of the invention will appear on examination of the detailed specification of a nonlimitative embodiment and of the attached drawings, in which:

BRIEF DESCRIPTION OF THE DRAWINGS

- Figure 1 is a flow chart of an embodiment of the method according to the invention;

- Figure 2 schematically illustrates two images obtained by a tomography system.

DETAILED DESCRIPTION OF THE INVENTION

Referring in particular to the three Figures 1, 3 and 4, first of all, the two digital images are acquired. Acquisition 1 makes it possible to obtain a scanner image 11 illustrated in Figure 3. This image represents a view of a patient's head along a given plane. A part outside the head can be distinguished there, that is, the air 12 represented in black. The white zone 14 corresponds to the bony tissues and all the grayish zones 13 correspond to the soft tissues. The scanner image 11 is of particular interest because it favors visualization of the bony tissue. Its principal characteristic is therefore a perfect display of the bony tissues 14. On the other hand, the grayish zones 13 have a poor resolution, so that it is impossible to distinguish the contrasts in the soft tissues.

Acquisition 2 makes it possible to obtain an image 15 by magnetic resonance imaging. It represents a view of a patient's head along the same plane as the scanner image 11. A black part 16 can also be distinguished there, corresponding to the air all around the head. Inside the head, the black zones 17 correspond to the bony tissues and to any element other than the soft tissues, like air, for example. The grayish zones 18 represent the soft tissues. The principal characteristic of that image is the display of soft tissues. The resolution is sufficient to distinguish contrasts, elements of interest 19. On the other hand, it is difficult to delimit the bony parts 17, for they are merged with the air and every other element appearing in black on the image 15.

These two images 11 and 15 originating from two different methods of acquisition 1 and 2 represent a view of the head along a given cutting plane. Thus, a two-dimensional recentering 3 is made in order to render the two images 11 and 15 superposable. For this purpose, rotation and/or translation operations are possibly carried out. There are tools known to the expert that make it possible to control the recentering operation 3. One can mention,

notably, the tool using a pointer, that is, a particular element is pointed to on the scanner image 11, for example, and a cursor appears on the same particular element on the MRI image 15. The same idea is exploited in the tool using a magnifier.

Once the two images 11 and 15 are recentered, one determines in stage 4 the lowest value A_{CT} of the soft tissues in the scanner image, for example, -130, which is a low value of soft tissues in the Hounsfield scale. One also determines the highest value B_{CT} of soft tissues in the scanner image, for example, 80, which is a high value of soft tissues in the Hounsfield scale. These two values are both CT numbers. A CT number is defined from the attenuation coefficient of the tissue considered and from the attenuation coefficient of water:

$$CT\ Number = \frac{\mu_0 - \mu_w}{\mu_w} x1000$$

with μ_w: attenuation coefficient of water

μ_0: attenuation coefficient of the tissue considered.

The CT number is expressed in Hounsfield unit.

Table of CT numbers

ELEMENTS OF THE HUMAN BODY	*CT NUMBER*
BONE (CORTEX)	> 250
BONE (MARROW)	130 ± 100
COAGULATED BLOOD	80 ± 10
THYROID GLAND	70 ± 10
LIVER	50 ± 10
MUSCLE	45 ± 5

BLOOD	40 ± 10
BRAIN (WHITE MATTER)	35 ± 5
KIDNEY	30 ± 10
BRAIN (GRAY MATTER)	25 ± 5
FATTY TISSUE	-100 ± 10

Two values A_{MR} and B_{MR} on the MRI image are also determined in stage 5. A_{MR} is a gray level such that the lower gray levels are considered black. B_{MR} is a gray level such that the higher gray levels are considered white.

One then proceeds with an algorithm 6 making possible scaling of the MR interval. According to a preferred embodiment of the invention, algorithm 6 is applied in accordance with Figure 2. A target pixel of the scanner image of gray level equal to V_{CT} is taken in the course of stage 6a. In the first place, it is going to be determined whether that value is included in the CT interval. For that purpose, both values of the lower limit A_{CT} and upper limit B_{CT} are introduced. First of all, the value V_{CT} is compared to value A_{CT} in the course of stage 6b. If the gray level of the target pixel V_{CT} is less than A_{CT}, then the target pixel is outside the CT interval and it can then correspond to the bony tissue 14 or to the black background 12 of the scanner image. In that case, the target pixel maintains its value V_{CT} on the final image 20.

Otherwise, if the gray level V_{CT} is higher than A_{CT}, it is compared in the course of stage 6c to value B_{CT}. If the gray level V_{CT} is higher than the upper limit B_{CT} of the CT interval, then the target pixel maintains its value V_{CT} on the final image 20 in the course of stage 6f, that is, V_{OUT}, the gray level of the target pixel on the final image 20, is equal to V_{CT}. Thus, for a value V_{CT} lower than A_{CT} or higher than B_{CT}, the level V_{CT} is maintained as gray level V_{OUT} of the final image 20.

On the other hand, if V_{CT} is higher than A_{CT} and lower than B_{CT}, the gray level V_{MR} of a pixel of the MRI image of the same coordinates as the target pixel of the scanner image is then determined in the course of stage 6d. It is then made to undergo a linear inter-polation at that gray level V_{MR} by introducing levels A_{CT}, B_{CT}, A_{MR} and B_{MR}. A new value V_{OUT} independent of V_{CT} is then obtained in the course of stage 6e.

Algorithm 6 is presented in that case in the form:

- if $V_{CT} < -130$, then

1) $V_{OUT} = V_{CT}$,

- if $V_{CT} > 80$, then

2) $V_{OUT} = V_{CT}$,

- if $-130 < V_{CT} < 80$, then

3) $V_{OUT} = -130 + (80 + 130) (V_{MR} - A_{MR})/(B_{MR} - A_{MR})$.

Whatever the values A_{MR} and B_{MR}, the final image 20 presents a range of gray levels according to the Hounsfield scale. Figure 5 shows the final image 20 in which the bony tissues 14 as well as the soft tissues 18 are distinguished. The background of the image 12 remains black, as on the scanner image 11.

However, for a scanner image obtained according to a view of the lungs, a pixel of gray level V_{CT} representing the lungs in the scanner image will have value V_{OUT} equal to V_{CT} in the final image, whatever the gray level V_{CT} included or not in the CT interval. In other words, if the gray levels of the lungs in the final image are the gray levels of the lungs in the scanner image, the linear interpolation is not applied on the gray levels of the lungs. This is due to the fact that the gray levels representing the lungs possess such dynamics that the scanner image has a better resolution than the MRI image.

The final image 20, whose gray levels are contained in the Hounsfield scale, was thus determined. This final image is then safeguarded in stage 7 in the form of a scanner image. It can be printed in stage 10 or even displayed in stage 8 on a screen for possible study. But the main advantage of that methods resides in the fact that this image can be delivered on entry of a standard radiotherapy treatment system in stage 9.

The final image originating from fusion of a scanner image with an MRI image reveals soft tissues as well as bony tissues and can be used a source for all standard scanner image processing software, such as Advantage Sim, Isis or even Advantage Windows Viewer.

Various modifications in structure and/or steps and/or function may be made by one skilled in the art without departing from the scope of the invention.

09/720541

528 Rec'd PCT/PTO 22 DEC 2000

PATENT
14XZ00074

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of
KNOPLIOCH ET AL

: CT/MRI FUSED IMAGE PRESENTATION ALGORITHM

Serial No.:

: Group Art Unit:

Filed: April 28, 1999

: Examiner:

December 22, 2000

PRELIMINARY AMENDMENT

BOX PCT
Assistant Commissioner for Patents
Washington, D.C. 20231

10/720541

Sir:

Before calculation of the official filing fee and before examination of the application please amend the application as follows:

IN THE ABSTRACT:

Delete the following text: "Reference: no figure"

"*[Keys to text in Fig. 2:]*"

"*OUI = YES*"

"*NON = NO*"

IN THE TITLE: Change the title to read: --METHOD AND SYSTEM OF FUSION OF TWO DIGITAL RADIOGRAPHIC IMAGES –

IN THE CLAIMS:

Cancel claims 1 to 10 and add new claims 11 to 24, as follows:

11. A method of fusion of first and second digital radiographic images of an object comprising the steps of:

scanning the object to provide first digital radiographic image;

provided the second digital radiographic image by magnetic resonance imaging (MRI); and

certify that this correspondence is being with the United States Postal Service as mail in an envelope addressed to: Commissioner of Patents and Trademarks, Washington, 20231, on 12/22/00

selecting in the scanner image a CT interval of gray wherein each pixel of the scanner image having a gray level lying within the CT interval is replaced by a pixel obtained by digital processing of the pixel of the same coordinates as the MRI image, the final image corresponding to the scanner image in which the pixels of gray levels lying within the CT interval are thus modified.

12. The method according to claim 11, wherein a two-dimensional recentering of both MRI and scanner images is carried out by means of at least one rotation and/or translation operation, so that a pixel of the scanner image of coordinates (x,y) and a pixel of the MRI image of the same coordinates (x,y) represent the same portion of the organ X-rayed.

13. The method according to claim 11 wherein the upper limit B_{CT} of the CT interval is fixed at a gray level value on the Hounsfield scale, the gray level corresponding to the highest value of the gray levels representing the soft tissues visualized on the scanner image.

14. The method according to claim 12 wherein the upper limit B_{CT} of the CT interval is fixed at a gray level value on the Hounsfield scale, the gray level corresponding to the highest value of the gray levels representing the soft tissues visualized on the scanner image.

15. The method according to claim 11 wherein the lower limit A_{CT} of the CT interval is fixed at a gray level value on the Hounsfield scale, the gray level corresponding to the lowest value of the gray levels representing soft tissues visualized on the scanner image.

16. The method according to claim 12 wherein the lower limit A_{CT} of the CT interval is fixed at a gray level value on the Hounsfield scale, the gray level corresponding to the lowest value of the gray levels representing soft tissues visualized on the scanner image.

17. The method according to claim 13 wherein the lower limit A_{CT} of the CT interval is fixed at a gray level value on the Hounsfield scale, the gray level corresponding to the lowest value of the gray levels representing soft tissues visualized on the scanner image.

18. The method according to claim 14 wherein the lower limit A_{CT} of the CT interval is fixed at a gray level value on the Hounsfield scale, the gray level corresponding to the lowest value of the gray levels representing soft tissues visualized on the scanner image.

19. The method according to claim 11 wherein one selects another MR interval of gray levels in the MRI image, whose upper limit B_{MR} corresponds to a gray level above which the pixels are white.

20. The method according to claim 19 wherein the lower limit A_{MR} of the MR interval corresponds to a gray level below which the pixels are black.

21. The method according to claim 11 wherein the digital processing consists of a linear interpolation.

22. The method according to claim 21 wherein the linear interpolation introduces an affine function integrating the value of the lower limit A_{CT} and upper limit B_{CT} of the CT interval in the scanner image and the value of the lower limit A_{MR} and upper limit B_{MR} of the MR interval in the MRI image.

23. The method according to claim 22 wherein a scanner pixel having a gray level V_{CT} lying within the CT interval, the gray level V_{MR} of the corresponding pixel in the MRI image is determined, and then a gray level in the CT interval is determined from the affine function and from the level V_{MR}; the gray level V_{OUT} of each pixel of the final image is then obtained by the following algorithm:

- if $V_{CT} < A_{CT}$, then

1) $V_{OUT} = V_{CT}$,

- if $V_{CT} > B_{CT}$, then

2) $V_{OUT} = V_{CT}$,

- if $A_{CT} < V_{CT} < B_{CT}$, then

3) $V_{OUT} = A_{CT} + (B_{CT} - A_{CT}) (V_{MR} - A_{MR})/(B_{MR} - A_{MR})$.

24. A system of fusion of first and second digital radiographic images comprising:

means for providing the first digital radiographic image by scanning;

means for providing the second digital radiographic image by MRI;

means for reading pixels of the scanner image, the gray levels of which lie within a predetermined CT interval;

means for reading pixels of the MRI image, the coordinates of which are identical to those of the pixels of the CT interval of the scanner image; and

means for calculation of a third image composed of the scanner image in which the pixels whose gray levels lie within the CT interval are replaced by pixels obtained by digital processing of the pixels of the same coordinates as the MRI image in order to obtain an image making possible visualization of the soft tissues and bony tissues.

REMARKS

This amendment formats the title, abstract, and claims in conformity with U.S. patent practice.

Respectfully submitted,
KNOPLIOCH ET AL

By ______________________
Jay L. Chaskin

3/PRTS

09/720541
528 Rec'd PCT/PTO 22 DEC 2000

METHOD AND SYSTEM OF FUSION OF TWO DIGITAL RADIOGRAPHIC IMAGES

BACKGROUND OF THE INVENTION

The invention concerns the fusion of two digital images of an object, the first image of which favors a particular constituent of the object, while the second image favors another.

It has a particularly important application in the medical field, in which a first image of a body organ obtained by scanning is fused with a second image of the same organ obtained by magnetic resonance imaging (MRI).

In fact, an image obtained by means of a scanner particularly reveals the bony part. In such an image, the bony part is white and all the other parts, especially, the soft tissues, are of a homogeneous gray without contrast. On the other hand, an image obtained by means of MRI reveals the soft tissues in different shades of gray levels and the other parts like the bony parts and empty space are black.

In general, in the medical field a scanner image is fused with an MRI image by integrating the pixels of the bony parts of the scanner image in the MRI image.

The scanner images possess an absolute scale of gray levels, that is, all the scanner images are compatible with one another, in the sense that a given gray level always represents a particular organ. This absolute scale is the Hounsfield scale, composed of positive and negative numbers, in which the 0 level is the gray level of water.

An MRI image does not possess an absolute scale. The gray levels depend on the patient and on the image acquisition conditions. Therefore, from one MRI image to another, the muscle, for example, as soft tissue, is not

represented by the same gray level. Thus, fusion of an MRI image with a scanner image results in a final image whose scale is not absolute.

In other words, the fusion of an image possessing an absolute scale with another image not possessing an absolutely scale results in a final image not possessing any absolute scale.

Furthermore, an image not possessing any absolute scale cannot be used by any of the current scanner image processing software. In fact, all of that software uses a standard gray level format, which is the Hounsfield scale. Thus, a final image originating from the fusion of both scanner and MRI images is incompatible with any scanner image processing software. It is necessary to develop specific image processing software not calibrated on the Hounsfield scale, in order to be able to use said final image.

The invention is aimed at introducing a solution to that problem by a scaling of the gray levels of the MRI image, in order to render the final image compatible with all scanner image processing software. In other words, the final image will be calibrated on the Hounsfield scale.

One object of the invention is to reduce the cost of investment in the development of specific software, if it is desired to carry out digital processing on said final image.

Another object of the invention is to use a final image of fusion obtained according to the method of the invention as image source for the standard radiotherapy software, which is not the case with the fused images in the present state of the art.

The invention therefore proposes a method of fusion of a first digital radiographic image obtained as a result of scanning with a second digital radiographic image obtained by magnetic resonance imaging (MRI).

According to a general characteristic of the invention, a CT interval of gray levels is selected in the scanner image and each pixel of said scanner image

having a gray level lying within the CT interval is replaced by a pixel obtained by digital processing of the pixel of the same coordinates as the MRI image. The final image therefore corresponds to the scanner image in which the pixels of gray levels lying within the CT interval are thus modified.

Furthermore, with a view to effective digital processing, a two-dimensional recentering of both MRI and scanner images is carried out by means of at least one rotation and/or translation operation, so that a pixel of the scanner image of coordinates (x,y) and a pixel of the MRI image of the same coordinates (x,y) represent the same portion of the organ X-rayed.

In other words, the range of gray levels corresponding to the soft tissues is replaced by a new range of gray levels. The values of the gray levels of that new range are obtained from an algorithm introducing certain gray levels of the MRI image. For a given pixel of the CT interval in the scanner image, the algorithm calculates the gray level value of the new pixel from a pixel of the MRI image having the same coordinates as the pixel of the CT interval having to be replaced.

According to one method of use of the invention, the upper limit B_{CT} of the CT interval is fixed at a gray level value on the Hounsfield scale, said gray level corresponding to the highest value of the gray levels representing the soft tissues visualized on the scanner image. The lower limit A_{CT} of the CT interval is fixed at a gray level value on the Hounsfield scale, said gray level corresponding to the lowest value of the gray levels representing soft tissues visualized on the scanner image.

More precisely, two thresholds are fixed, defining the CT interval corresponding to the soft tissues in the scanner image.

In practice, B_{CT} is fixed as the highest value of the soft tissues in the scanner image and A_{CT} is fixed as the lowest value of the soft tissues in the scanner image.

The interval thus selected is an interval included in the Hounsfield scale, since the scanner image is calibrated on that scale.

In general, according to one method of use of the invention, one selects an MR interval of gray levels in the MRI image, whose upper limit B_{MR} corresponds to a gray level above which the pixels are white, and whose lower limit A_{MR} corresponds to a gray level below which the pixels are black.

In other words, that interval takes into account all of the variation of gray levels in the MRI image. This variation, this contrast, represents the useful information on the soft tissues.

There are then two intervals, a first CT interval in the scanner image included in the Hounsfield scale and a second MR interval in the MRI image not linked to the Hounsfield scale. These two intervals represent a framing of the soft tissues.

According to a method of use of the invention, the digital processing consists of a linear interpolation by means of an affine function integrating the value of the lower limit A_{CT} and upper limit B_{CT} of the CT interval in the scanner image and the value of the lower limit A_{MR} and upper limit B_{MR} of the MR interval in the MRI image.

Carrying out a linear interpolation makes it possible to respect the choice of contrast in the MRI image.

Preferably, for a scanner pixel having a gray level V_{CT} lying within the CT interval, the gray level V_{MR} of the pixel of the same coordinates in the MRI image is determined, and then a gray level in the CT interval is determined from said affine function and from said level V_{MR}. The gray level V_{OUT} of each pixel of the final image can then be obtained by the following algorithm:

- if $V_{CT} < A_{CT}$, then

1) $V_{OUT} = V_{CT}$,

- if $V_{CT} > B_{CT}$, then

2) $V_{OUT} = V_{CT}$,

- if $A_{CT} < V_{CT} < B_{CT}$, then

3) $V_{OUT} = A_{CT} + (B_{CT} - A_{CT})(V_{MR} - A_{MR})/(B_{MR} - A_{MR})$.

In other words, while maintaining the resolution of the MRI image, the MRI image is scaled so that the black level A_{MR} of the MRI image corresponds to the lowest value A_{CT} of the soft tissues in the scanner image. Likewise, the white level B_{MR} of the MRI image corresponds to the highest value B_{MR} of the soft tissues in the scanner image.

In fact:

- for $V_{MR} = B_{MR}$, highest gray level in the MR interval of the MRI image,

one obtains by 3) $V_{OUT} = B_{CT}$, highest gray level in the CT interval of the scanner image,

- and for $V_{MR} = A_{MR}$, lowest gray level in the MR interval of the MRI image,

one obtains by 3) $V_{OUT} = A_{CT}$, lowest gray level in the CT interval of the scanner image.

Scaling causes the MR interval not calibrated on the Hounsfield scale of the MRI image to undergo a digital processing which makes it correspond to the CT interval lying within the Hounsfield interval.

Thus, all the gray level values V_{OUT} of the final image will be contained in the Hounsfield scale, which is the standard scale of scanner image processing.

The invention also concerns a system of fusion of a first digital radiographic image obtained by scanning with a second digital radiographic

image obtained by MRI, comprising:

- a means of reading pixels of the scanner image, the gray levels of which lie within a predetermined CT interval,

- a means of reading pixels of the MRI image, the coordinates of which are identical to those of the pixels of the CT interval of the scanner image,

- a means of calculation of a third image composed of the scanner image in which the pixels whose gray levels lie within the CT interval are replaced by pixels obtained by digital processing of the pixels of the same coordinates as the MRI image in order to obtain an image making possible visualization of the soft tissues and bony tissues.

The final image obtained is of the scanner type. It can therefore be processed by standard software such as Advantage Sim or even Advantage Windows 3D Viewer, which is not the case with the fusion images of the prior art. The methods of the prior art require the use of specific software in order to be able to process their fusion images.

Other advantages and characteristics of the invention will appear on examination of the detailed specification of a nonlimitative embodiment and of the attached drawings, in which:

BRIEF DESCRIPTION OF THE DRAWINGS

- Figure 1 is a flow chart of an embodiment of the method according to the invention;

- Figure 2 schematically illustrates two images obtained by a tomography system.

DETAILED DESCRIPTION OF THE INVENTION

Referring in particular to the three Figures 1, 3 and 4, first of all, the two digital images are acquired. Acquisition 1 makes it possible to obtain a scanner

image 11 illustrated in Figure 3. This image represents a view of a patient's head along a given plane. A part outside the head can be distinguished there, that is, the air 12 represented in black. The white zone 14 corresponds to the bony tissues and all the grayish zones 13 correspond to the soft tissues. The scanner image 11 is of particular interest because it favors visualization of the bony tissue. Its principal characteristic is therefore a perfect display of the bony tissues 14. On the other hand, the grayish zones 13 have a poor resolution, so that it is impossible to distinguish the contrasts in the soft tissues.

Acquisition 2 makes it possible to obtain an image 15 by magnetic resonance imaging. It represents a view of a patient's head along the same plane as the scanner image 11. A black part 16 can also be distinguished there, corresponding to the air all around the head. Inside the head, the black zones 17 correspond to the bony tissues and to any element other than the soft tissues, like air, for example. The grayish zones 18 represent the soft tissues. The principal characteristic of that image is the display of soft tissues. The resolution is sufficient to distinguish contrasts, elements of interest 19. On the other hand, it is difficult to delimit the bony parts 17, for they are merged with the air and every other element appearing in black on the image 15.

These two images 11 and 15 originating from two different methods of acquisition 1 and 2 represent a view of the head along a given cutting plane. Thus, a two-dimensional recentering 3 is made in order to render the two images 11 and 15 superposable. For this purpose, rotation and/or translation operations are possibly carried out. There are tools known to the expert that make it possible to control said recentering operation 3. One can mention, notably, the tool using a pointer, that is, a particular element is pointed to on the scanner image 11, for example, and a cursor appears on the same particular element on the MRI image 15. The same idea is exploited in the tool using a magnifier.

Once the two images 11 and 15 are recentered, one determines in stage 4 the lowest value ACT of the soft tissues in the scanner image, for example, -130,

which is a low value of soft tissues in the Hounsfield scale. One also determines the highest value B_{CT} of soft tissues in the scanner image, for example, 80, which is a high value of soft tissues in the Hounsfield scale. These two values are both CT numbers. A CT number is defined from the attenuation coefficient of the tissue considered and from the attenuation coefficient of water:

$$CT\ Number = \frac{\mu_0 - \mu_w}{\mu_w} x1000$$

with μ_w: attenuation coefficient of water

μ_0: attenuation coefficient of the tissue considered.

The CT number is expressed in Hounsfield unit.

Table of CT numbers

ELEMENTS OF THE HUMAN BODY	*CT NUMBER*
BONE (CORTEX)	> 250
BONE (MARROW)	130 ± 100
COAGULATED BLOOD	80 ± 10
THYROID GLAND	70 ± 10
LIVER	50 ± 10
MUSCLE	45 ± 5
BLOOD	40 ± 10
BRAIN (WHITE MATTER)	35 ± 5
KIDNEY	30 ± 10
BRAIN (GRAY MATTER)	25 ± 5
FATTY TISSUE	-100 ± 10

Two values A_{MR} and B_{MR} on the MRI image are also determined in stage 5. A_{MR} is a gray level such that the lower gray levels are considered black. B_{MR} is a gray level such that the higher gray levels are considered white.

One then proceeds with an algorithm 6 making possible scaling of the MR interval. According to a preferred embodiment of the invention, algorithm 6 is applied in accordance with Figure 2. A target pixel of the scanner image of gray level equal to V_{CT} is taken in the course of stage 6a. In the first place, it is going to be determined whether that value is included in the CT interval. For that purpose, both values of the lower limit A_{CT} and upper limit B_{CT} are introduced. First of all, said value V_{CT} is compared to value A_{CT} in the course of stage 6b. If the gray level of the target pixel V_{CT} is less than A_{CT}, then the target pixel is outside the CT interval and it can then correspond to the bony tissue 14 or to the black background 12 of the scanner image. In that case, the target pixel maintains its value V_{CT} on the final image 20.

Otherwise, if the gray level V_{CT} is higher than A_{CT}, it is compared in the course of stage 6c to value B_{CT}. If the gray level V_{CT} is higher than the upper limit B_{CT} of the CT interval, tnen said target pixel maintains its value V_{CT} on the final image 20 in the course of stage 6f, that is, V_{OUT}, the gray level of the target pixel on the final image 20, is equal tc V_{CT}. Thus, for a value V_{CT} lower than A_{CT} or higher than B_{CT}, said level V_{CT} is maintained as gray level V_{OUT} of the final image 20.

On the other hand, if V_{CT} is higher than A_{CT} and lower than B_{CT}, the gray level V_{MR} of a pixel of the MRI image of the same coordinates as said target pixel of the scanner image is then determined in the course of stage 6d. It is then made to undergo a linear inter-polation at that gray level V_{MR} by introducing levels A_{CT}, B_{CT}, A_{MR} and B_{MR}. A new value V_{OUT} independent of V_{CT} is then obtained in the course of stage 6e.

Algorithm 6 is presented in that case in the form:

- if $V_{CT} < -130$, then

1) $V_{OUT} = V_{CT}$,

- if $V_{CT} > 80$, then

2) $V_{OUT} = V_{CT}$,

- if $-130 < V_{CT} < 80$, then

3) $V_{OUT} = -130 + (80 + 130) (V_{MR} - A_{MR})/(B_{MR} - A_{MR})$.

Whatever the values A_{MR} and B_{MR}, the final image 20 presents a range of gray levels according to the Hounsfield scale. Figure 5 shows said final image 20 in which the bony tissues 14 as well as the soft tissues 18 are distinguished. The background of the image 12 remains black, as on the scanner image 11.

However, for a scanner image obtained according to a view of the lungs, a pixel of gray level V_{CT} representing said lungs in the scanner image will have value V_{OUT} equal to V_{CT} in the final image, whatever the gray level V_{CT} included or not in the CT interval. In other words, if the gray levels of the lungs in the final image are the gray levels of the lungs in the scanner image, the linear interpolation is not applied on the gray levels of the lungs. This is due to the fact that the gray levels representing the lungs possess such dynamics that the scanner image has a better resolution than the MRI image.

The final image 20, whose gray levels are contained in the Hounsfield scale, was thus determined. This final image is then safeguarded in stage 7 in the form of a scanner image. It can be printed in stage 10 or even displayed in stage 8 on a screen for possible study. But the main advantage of that methods resides in the fact that this image can be delivered on entry of a standard radiotherapy treatment system in stage 9.

The final image originating from fusion of a scanner image with an MRI image reveals soft tissues as well as bony tissues and can be used a source for all standard scanner image processing software, such as Advantage Sim, Isis or even Advantage Windows Viewer.

Various modifications in structure and/or steps and/or function may be made by one skilled in the art without departing from the scope of the invention.

WHAT IS CLAIMED IS:

1. Method of fusion of a first digital radiographic image obtained as a result of scanning with a second digital radiographic image obtained by magnetic resonance imaging (MRI), in which a CT interval of gray levels is selected in the scanner image and each pixel of said scanner image having a gray level lying within the CT interval is replaced by a pixel obtained by digital processing of the pixel of the same coordinates as the MRI image, the final image corresponding to the scanner image in which the pixels of gray levels lying within the CT interval are thus modified.

2. Method according to Claim 1, characterized in that a two-dimensional recentering of both MRI and scanner images is carried out by means of at least one rotation and/or translation operation, so that a pixel of said scanner image of coordinates (x,y) and a pixel of the MRI image of the same coordinates (x,y) represent the same portion of the organ X-rayed.

3. Method according to one of the foregoing claims, characterized in that the upper limit B_{CT} of the CT interval is fixed at a gray level value on the Hounsfield scale, said gray level corresponding to the highest value of the gray levels representing the soft tissues visualized on the scanner image.

4. Method according to one of the foregoing claims, characterized in that the lower limit A_{CT} of the CT interval is fixed at a gray level value on the Hounsfield scale, said gray level corresponding to the lowest value of the gray levels representing soft tissues visualized on the scanner image.

5. Method according to one of the foregoing claims, characterized in that one selects another MR interval of gray levels in the MRI image, whose upper limit B_{MR} corresponds to a gray level above which the pixels are white.

6. Method according to Claim 5, characterized in that the lower limit A_{MR} of the MR interval corresponds to a gray level below which the pixels are black.

7. Method according to one of the foregoing claims, characterized in that the digital processing consists of a linear interpolation.

8. Method according to Claim 7, characterized in that the linear interpolation introduces an affine function integrating the value of the lower limit A_{CT} and upper limit B_{CT} of the CT interval in the scanner image and the value of the lower limit A_{MR} and upper limit B_{MR} of the MR interval in the MRI image.

9. Method according to Claim 8, characterized in that for a scanner pixel having a gray level V_{CT} lying within the CT interval, the gray level V_{MR} of the corresponding pixel in the MRI image is determined, and then a gray level in the CT interval is determined from said affine function and from said level V_{MR}; the gray level V_{OUT} of each pixel of the final image is then obtained by the following algorithm:

- if $V_{CT} < A_{CT}$, then

1) $V_{OUT} = V_{CT}$,

- if $V_{CT} > B_{CT}$, then

2) $V_{OUT} = V_{CT}$,

- if $A_{CT} < V_{CT} < B_{CT}$, then

3) $V_{OUT} = A_{CT} + (B_{CT} - A_{CT}) (V_{MR} - A_{MR})/(B_{MR} - A_{MR})$.

10. System of fusion of a first digital radiographic image obtained by scanning with a second digital radiographic image obtained by MRI, characterized in that it comprises:

- a means of reading pixels of the scanner image, the gray levels of which lie within a predetermined CT interval,

- a means of reading pixels of the MRI image, the coordinates of which are identical to those of the pixels of the CT interval of the scanner image,

- a means of calculation of a third image composed of the scanner image in which the pixels whose gray levels lie within the CT interval are replaced by pixels obtained by digital processing of the pixels of the same coordinates as the MRI image in order to obtain an image making possible visualization of the soft tissues and bony tissues.

METHOD AND SYSTEM OF FUSION OF TWO DIGITAL RADIOGRAPHIC IMAGES

ABSTRACT OF THE DISCLOSURE

Method of fusion of a first digital radiographic image obtained as a result of scanning with a second digital radiographic image obtained by magnetic resonance imaging (MRI).

A CT interval of gray levels is selected first in the scanner image. Each pixel of the scanner image having a gray level lying within the CT interval is then replaced by a pixel obtained by digital processing of the pixel of the same coordinates as the MRI image.

Then, the final image corresponds to the scanner image in which the pixels of gray levels lying within the CT interval have undergone said digital processing.

Reference: no figure.

[Keys to text in Fig. 2:]

OUI = YES

NON = NO

FIG.1

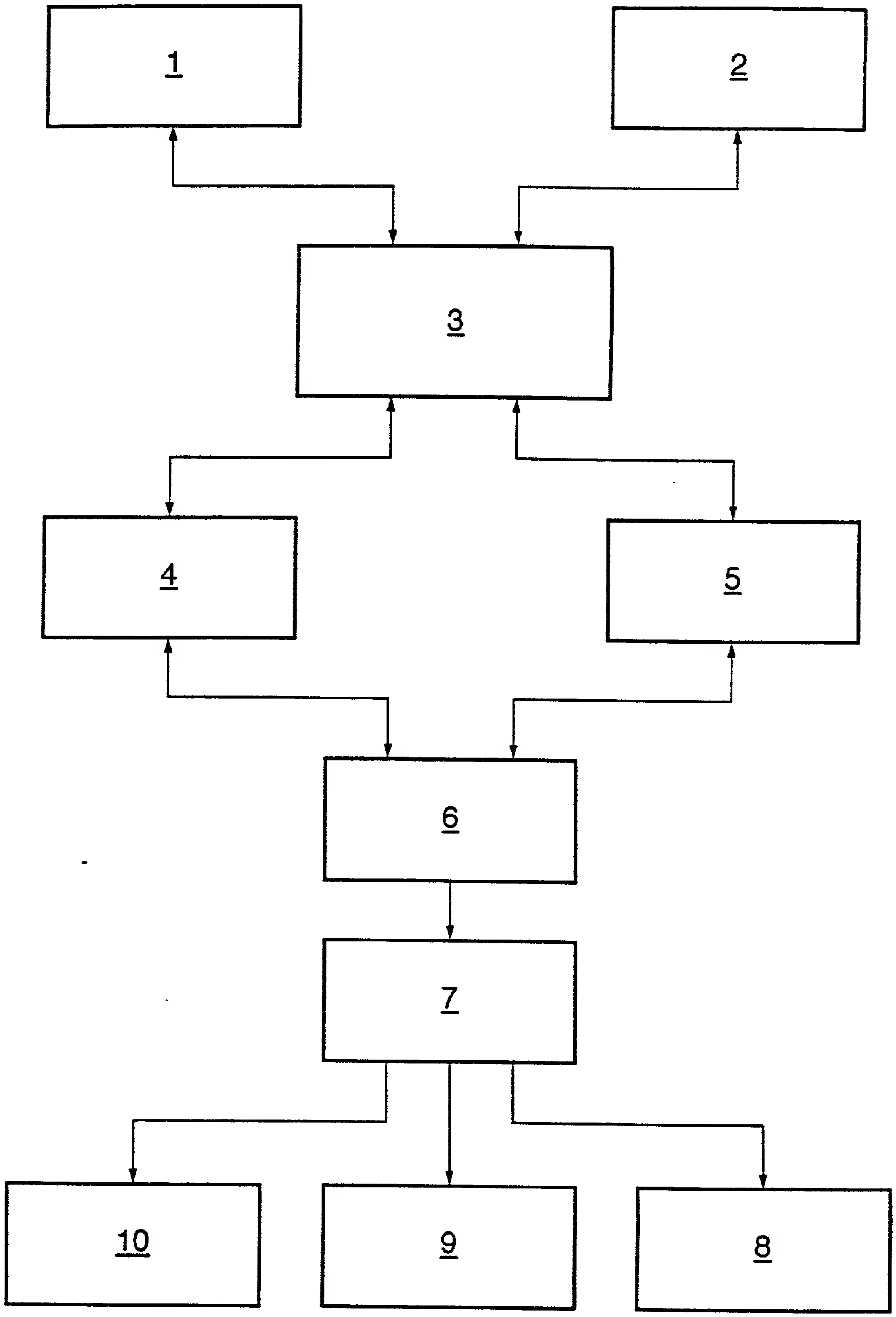
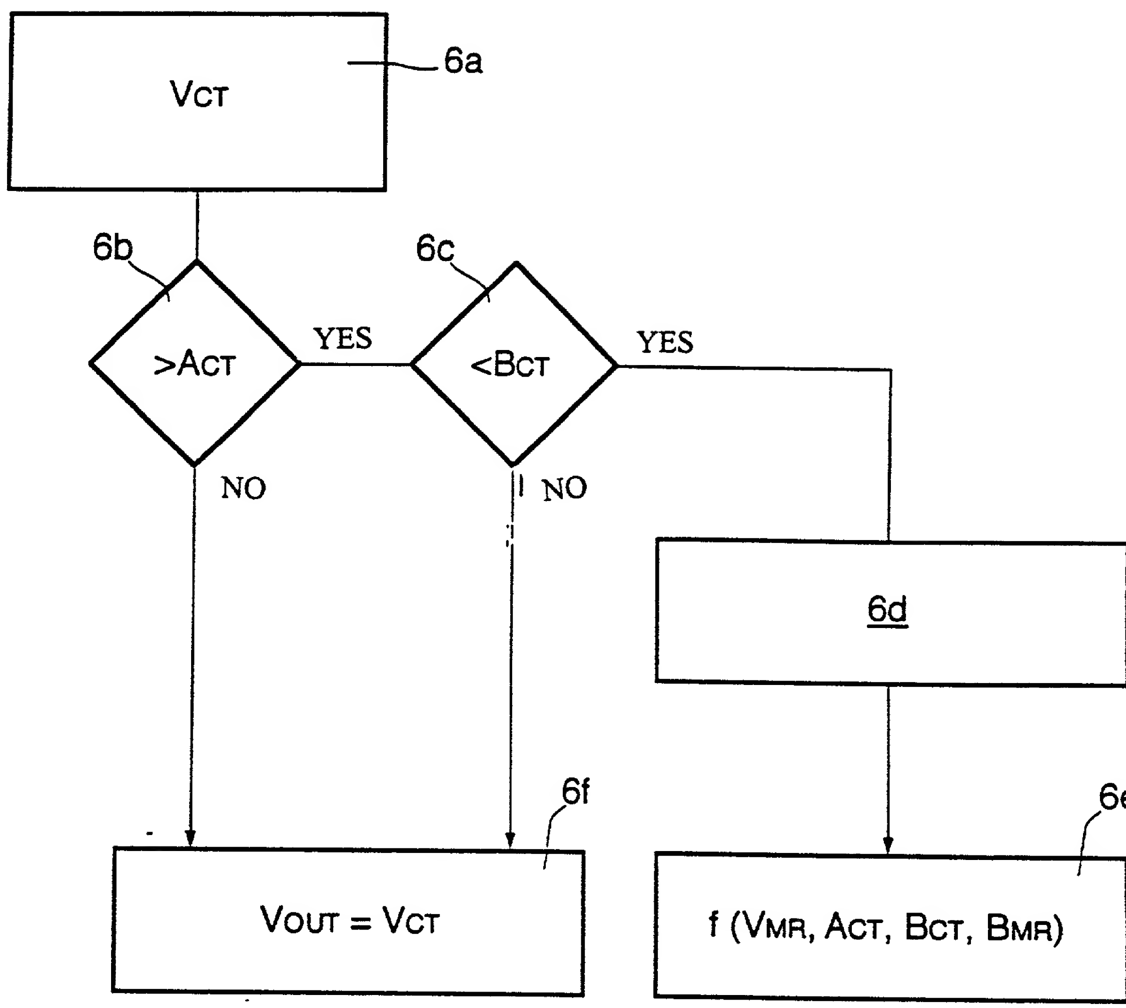


FIG.2


VCT
6a
6b
>ACT
YES
6c
<BCT
YES
NO
NO
6d
6f
6e
VOUT = VCT
f (VMR, ACT, BCT, BMR)

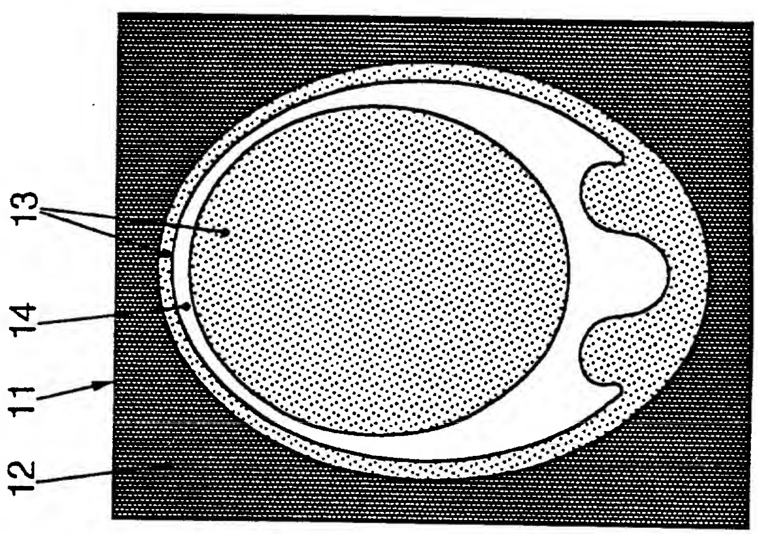


FIG.3

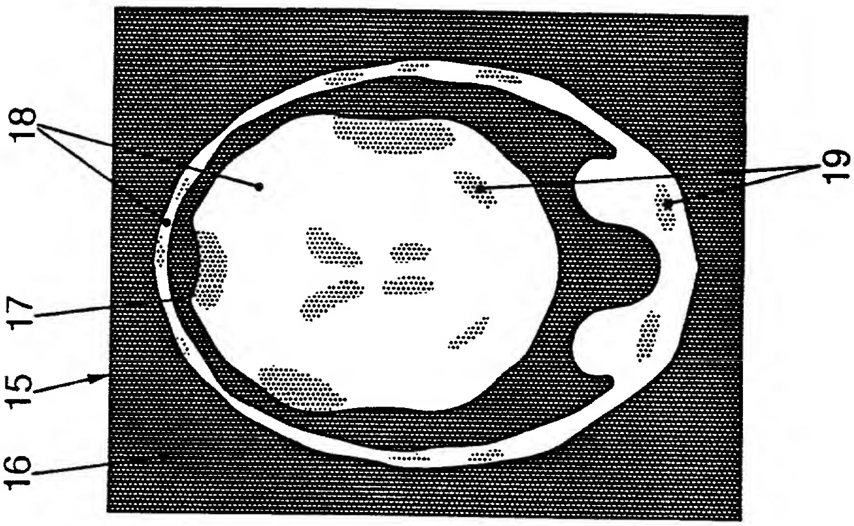


FIG.4

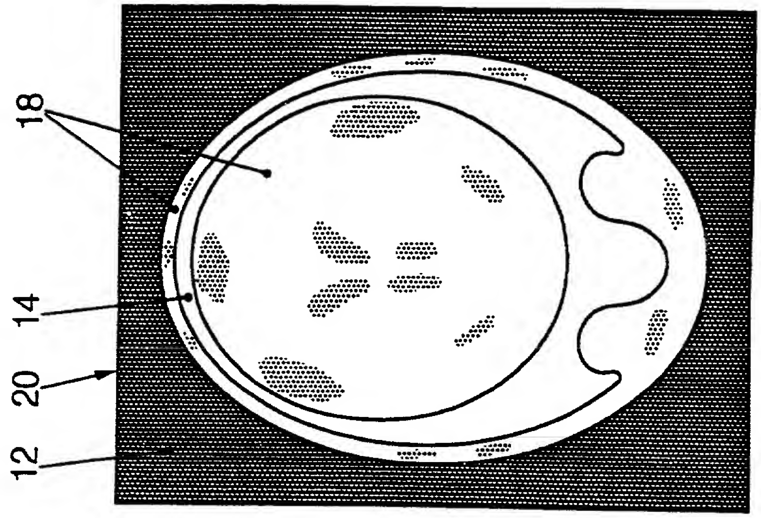


FIG.5

#3

PATENT
Docket No. 14XZ00074

COMBINED DECLARATION AND POWER OF ATTORNEY FOR PATENT APPLICATION

As a below-named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

METHOD AND SYSTEM OF FUSION OF TWO DIGITAL RADIOGRAPHIC IMAGES

the specification of which is attached hereto OR

was filed on 28 April 2000 as Application Serial No. or PCT International Application Number PCT/IB00/00606 (PCT/US00/11617) and was amended on (if applicable).

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with 37 CFR §1.56.

I hereby claim foreign priority benefits under 35 U.S.C.§119(a)-(d) or 365(b) of any foreign application for patent or inventor's certificate listed below, and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

COUNTRY	APPLICATION NUMBER	DATE OF FILING (day, month, year)	PRIORITY CLAIMED UNDER 37 U.S.C. 119
France	99 05438	29 April 1999	☒ Yes ☐ No
			☐ Yes ☐ No

I hereby claim the benefit under 35 U.S.C. §120 of any United States application(s), or 365(c) of any PCT International application designating the United States of America, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of 35 U.S.C. §112, I acknowledge the duty to disclose material information as defined in 37 CFR §1.56 which occurred between the filing date of the prior application and the national or PCT international filing date of this application:

U.S. PARENT APPLICATION OR PCT PARENT NUMBER	PARENT FILING DATE (day, month, year)	STATUS (patent and number, pending, abandoned)
PCT/IB00/00606 (PCT/US00/11617)	28 April 2000	Pending

I hereby claim the benefit under 35 U.S.C. 119(e) of any United States provisional application(s)listed below.

APPLICATION NUMBERS (S)	FILING DATE (day, month, year)

As a named inventor, I hereby appoint Christian G. Cabou (Reg. No. 35,467) and Phyllis Y. Price (Reg. No. 34,234) both of GE Medical Systems, 3000 North Grandview Blvd., Waukesha, Wisconsin 53188; Ronald E. Myrick (Reg. No. 26,315), Henry J. Policinski, (Reg. No. 26,621), and Jay L. Chaskin, (Reg. No. 24,030) all of General Electric Company, 3135 Easton Turnpike, Fairfield, Connecticut 06431-0001, jointly and each of them severally, my attorneys, with full power of substitution, delegation and revocation, to prosecute this application, to make alterations and amendments therein, to receive the patent and to transact all business in the Patent and Trademark Office connected therewith.

5

I hereby direct that all correspondence and telephone calls in connection with this application be addressed to Jay L. Chaskin, General Electric Company, 3135 Easton Turnpike, Fairfield, Connecticut 06431-0001, telephone number: 203-373-2867, fax number: 203-373-3991.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that all such willful false statements may jeopardize the validity of the application or any patent issued thereon.

1-00

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Full name of fifth joint inventor:

Inventor's signature: ______________________ Date: ______________

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Citizenship:

Post Office Address: same as residence

Full name of sixth joint inventor:

Inventor's signature: ______________________ Date: ______________________

Residence:
Citizenship:
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Full name of seventh joint inventor:

Inventor's signature: ______________________ Date: ______________________

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Post Office Address: same as residence